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Herbicides

How They Work and the Symptoms They Cause

Growth Regulator Herbicides

Amino Acid Synthesis Inhibitors

Cell Membrane Disruptors and Organic Arsenicals

Lipid Synthesis Inhibitors

Pigment Inhibitors

Seedling Growth Inhibitors

Photosynthesis Inhibitors

Paul A. Baumann, Professor and Extension Weed Specialist
Peter A. Dotray, Professor and Extension Weed Specialist
Eric P. Prostko, Assistant Professor and Extension Agronomist

The Texas A&M University System

Introduction

Whether you are producing agricultural crops or tending a lawn or home garden, weed control will be important to your success. Weeds can be controlled mechanically, culturally, biologically, and chemically, and all these methods may be important in an integrated weed control program that is economical and friendly to the environment.

Chemical control with herbicides has been an important tool for managing weeds in crops and home landscapes for many years. Many of today's herbicides are more effective and selective. These traits make them less harmful to the environment when they are used properly. Although herbicides are widely used, few people understand how they work to control undesirable plants.

Herbicide application

Generally speaking, herbicides are applied either preemergence or postemergence. That means they are applied either before or after weeds emerge from the soil and begin to grow. Preemergence herbicides kill weeds shortly after they germinate or emerge through the soil surface. Postemergence herbicides control weeds that are already growing and easily visible.

Some herbicides are applied to the soil and are taken up by seedling plant roots or shoots. They are said to have soil activity. Herbicides that are applied to plant foliage have foliar activity. Some herbicides have both. Herbicides with a high degree of soil activity usually are applied preemergence.

Selectivity

Selectivity is the process by which a herbicide controls or kills certain plants but leaves others unharmed. Selectivity may be as simple as controlling broadleaf plants but not grass plants. Many new herbicides have more sophisticated selectivity that differentiates between several broadleaf and/or several grass plants.

Herbicides with no selectivity, such as Roundup Ultra®, are called nonselective. These products kill all types of plants. Selectivity usually depends on the time or placement of the herbicide applied. Most herbicides can be harmful, even to normally tolerant plants, if the dose is too high.

Translocation

Some herbicides move (translocate) within the plant. Systemic herbicides translocate once they are taken up by the leaves, stems or roots. Herbicides that do not move after they enter the plant are called contact herbicides. Some products can be either contact or systemic herbicides, depending on the way they are applied.

Mode of action

Mode of action refers to the effect a herbicide has on a plant. Herbicides work in many different ways. If we understand a herbicide's mode of action, we will know what symptoms it produces at lethal or sublethal doses.

Other problems such as disease, nutrient deficiency, and insect damage may mimic the effects of herbicides. These other possibilities must be ruled out before herbicide injury is diagnosed. The following mode of action categories cover most of the herbicides used in Texas.

Today's herbicides are more effective and selective.

Growth Regulator Herbicides

Phenoxy herbicide drift onto cotton

These herbicides are very versatile for weed control.

These herbicides are widely used to control broadleaf weeds in grass crops such as wheat, corn, sorghum, forages, and turf grasses. One member of this group, 2, 4-D, was one of the first selective herbicides developed. Growth regulator herbicides upset the normal hormonal balance that regulates processes such as cell division, cell enlargement, protein synthesis, and respiration. That is why this group of herbicides is sometimes called the "hormone herbicides." These herbicides are very versatile for weed control. They usually are applied to the foliage, but are also effective in the soil. Any herbicide that falls on the soil instead of the foliage can be percolated into the soil with rain or irrigation and will be taken up by weed roots.

Herbicides in this category

Phenoxy growth regulator herbicides have the least plant activity and soil residual activity; the carboxylic acids generally have the most. Broadleaf crops and turf grasses should not be planted into soils recently treated with these herbicides because they severely inhibit seedling emergence.

Family	Common Name	Trade Name(s)
phenoxy	2,4-D	Several
	2,4-DB	Butyrac®, Butoxone®
	MCPA	Several
	MCPP	Several
	MCPB	Several
benzoic acid	dicamba	Banvel®, Clarity®
carboxylic acid	picloram	Tordon 22K®
	clopyralid	Stinger®, Reclaim®
	triclopyr	Remedy®, Grandstand®
	quinclorac	Facet®

Dicamba drift onto soybeans

Symptoms

The most common symptoms for these herbicides are leaf and stem malformations. In broadleaf plants stems curl, twist, and droop, while leaves are cupped, crinkled, or have a "drawstring" appearance caused by irregular growth at the leaf edges. In cotton plants, points develop on leaf edges. Overapplication or application at the wrong stage of development in corn can cause leaf rolling and crinkling, brace root malformation, sterile flowers, and missing grain (blasting). Blasting and malformed seed heads are common symptoms of ill-timed applications in wheat.

Special considerations

Vapor from these products can easily drift to desirable plants, so they must be applied carefully. Equipment should be cleaned according to label instructions before it is used to treat susceptible crops with other herbicides.

Dicamba injury to corn

Photosynthesis Inhibitors

Herbicides in this category inhibit photosynthesis, the process by which all green plants convert light energy from the sun into sugars (food). Photosynthesis inhibitors are broadleaf herbicides, but also control annual grasses to some extent.

Herbicides such as Buctril®, Basagran® and Tough® are used as foliar, selective, postemergence products. Others such as atrazine, Bladex®, Caparol®, or Cotoran® are generally used as pre-emergence herbicides, but are sometimes used postemergence. Their selectivity when applied postemergence depends on the crop and application method.

Herbicides in this category

Several herbicides in this category are critical to cotton, corn, and rice production in Texas.

Family	Common Name	Trade Name(s)
triazine	atrazine	AAtrex®, others
	cyanazine	Bladex®, others
	prometryn	Caparol®, others
	propazine	
	simazine	Princep®, others
triazinone	hexazinone	Velpar®
	metribuzin	Sencor®, Lexone®
uracil	terbacil	Sinbar®
	bromacil	Hyvar®
	bromacil + diuron	Krovar®
nitrile	bromoxynil	Buctril®
benzothiadiazole	bentazon	Basagran®
phenyl-pyridazine	pyridate	Tough®
urea	diuron	Karmex®, others
	fluometuron	Cotoran®, others
	linuron	Lorox®, others
	siduron	Tupersan®
	tebuthiuron	Spike®
amide	propanil	Stam®

Metribuzin damage to soybeans

Symptoms

Symptoms depend on the product's mobility within the plant. Herbicides in the triazine, triazone, uracil, and urea families move within the plant and exhibit these symptoms in older leaves first: yellowing between the leaf veins or in the veins, and yellowing of the leaf margins that eventually turn brown and die. Herbicides in the benzothiadiazole, nitrile, phenyl-pyridazine, and amide families are not mobile within the plant and affect only treated leaves. Symptoms include speckling, spotting, and yellowing or bronzing that may kill affected tissue.

Special considerations

Soil pH higher than 7.2 can make injury from the triazine and triazone families more severe when used preemergence.

Triazine carryover damage to cotton

Triazine damage to cotton

Bromoxynil damage on corn

Photosynthesis inhibitors are broadleaf herbicides.

Pigment Inhibitors

Clomazone damage in peanuts

These herbicides are often described as "bleaching herbicides."

Herbicides classified as pigment inhibitors destroy the green pigment (chlorophyll) in leaf tissue. Chlorophyll is necessary for photosynthesis; without it, plants die. These herbicides are often described as "bleaching herbicides" because they cause new leaves to appear yellow or white.

These herbicides are absorbed by roots and translocate to the shoot tissue where they inhibit the production of carotenoids—substances that protect the chlorophyll molecules that make plants green. Without carotenoids, chlorophyll is destroyed. These herbicides do not destroy carotenoids already formed, but prevent the formation of new ones.

Herbicides in this category

There are three families of herbicides that bleach plant tissue.

Family	Common Name	Trade Name(s)
isoxazol	clomazone isoxaflutole	Command® Balance®
pyridazinone	norflurazon	Zorial®, Evital®, Solicam®
triazole	amitrole	Amitrol®

Symptoms

Injured leaves turn yellow or white, then often translucent. New growth is yellow to white with sometimes a hint of purple or pink. These symptoms can be found on cotyledons to the newest leaves of susceptible plants. Zorial® initially causes bleaching within veins; Command® initially causes bleaching between veins.

Clomazone damage in cotton

Special considerations

In order to use Command® in cotton, an organophosphate insecticide (Thimet® or Di-Syston®) must be used in-furrow first. If the insecticide is placed incorrectly or applied at the wrong rate, cotton may be injured. Some formulations of Command® are volatile and should be used with care. Consult the label for further precautions.

Norflurazon carryover damage in corn

Seedling Growth Inhibitors

Some herbicides act on seedling weeds shortly after they germinate and before they emerge. These herbicides work beneath the soil so their effects are seldom seen. If overapplied, however, they may inhibit growth of weed or crop seedlings that do emerge through the soil surface. These herbicides can be divided into two groups—root inhibitors and shoot inhibitors.

Root inhibitors. These herbicides interrupt cell division, which stops root growth in seedling weeds. Plants die because they cannot take up enough water and nutrients to sustain growth. The root inhibitors are most effective on small-seeded broadleaf and grass weeds. Large-seeded weeds and crops generally survive normal dosages because their roots and shoots grow through the herbicide-treated zone in the soil.

Shoot inhibitors. The seedling shoot growth inhibitors also act on newly germinated weed seeds. They are absorbed by the seedling shoots of grasses and roots of broadleaf plants, and they disrupt cell growth. They are most effective at controlling small-seeded grass and broadleaf weeds. Large-seeded crops and weeds are not usually affected. Once tolerant or susceptible plants emerge they can generally overcome the effects of the herbicide.

Symptoms

Root inhibitors. Injury to tolerant plants is caused by root damage. Grass crops may be stunted and have a purple discoloration because roots cannot take up enough phosphorus. Root systems appear stubby and thick, especially the lateral roots. Broadleaf plants may have swollen and cracked hypocotyls. If these herbicides are incorporated shallowly or applied preemergence, they sometimes cause callus tissue (tumors) to form on the plant stem at the soil surface. This weakens the stem and causes lodging. Dinitroaniline herbicides applied postemergence to broadleaf crops may cause stunting.

Shoot inhibitors. Symptoms caused by the shoot inhibitors are much different than those of the root inhibitors. Overapplication or extended periods of cool, wet weather shortly after planting may sometimes cause injury to tolerant crops such as corn or sorghum. Symptoms include leafing out underground, improper leaf unfurling (shepherd's crooking), buggy whipping (tightly rolled leaves), and leaf crinkling. In broadleaf plants, the center vein (midrib) may draw in the leaf edge in a drawstring effect. Leaf puckering is also a symptom on broadleaf plants. There may also be stunting that persists until the soil warms enough to promote plant growth.

Herbicides in this category

These products are widely used in Texas row crops, turfgrass, and horticultural crops.

Family	Common Name	Trade Name(s)
dinitroanilines (root inhibitors)	benefin	Balan®
	ethalfluralin	Sonalan®, Curbit®
	oryzalin	Surflan®
	pendimethalin	Prowl®, Pentagon®
	trifluralin	Treflan®, others
	oryzalin + benefin	XL®
	trifluralin + benefin	Team®
acetamides (shoot inhibitors)	acetochlor	Harness®, Surpass®, Topnotch®
	alachlor	Lasso®, MicroTech®
	butachlor	Machete®
	metolachlor	Dual®, Dual II®, Dual Magnum®, others
	pronamide	Kerb®
	propachlor	Ramrod®
	dimethenamid	Frontier®
	napropamide	Devrinol®

Special considerations

The growth inhibitor herbicides have no postemergence activity; therefore, the timing of application is critical. Dinitroanilines have various requirements for incorporation into the soil. Consult the individual product label for specific recommendations. Grain sorghum treated with Concep® seed safener is tolerant to the acetamide herbicides.

Acetamide herbicide damage to corn

If overapplied, they may inhibit growth of weed or crop seedlings.

Dinitroaniline herbicide damage to corn seedling

Dinitroaniline herbicide damage to soybeans

Cell Membrane Disrupters and Organic Arsenicals

Diphenylether injury to soybeans

The effects of the bipyridilium herbicides are rapid.

The cell membrane disruptor postemergence herbicides control both grasses and broadleaf weeds by destroying cell membranes and causing rapid dessication of the plant. There are two types of cell membrane disruptor herbicides: the bipyridiliums and the diphenylethers. The bipyridilium herbicides require thorough plant coverage to be effective, and they have no soil activity. The diphenylether herbicides act in a similar way but more slowly. Some of them are more selective between crops and weeds. The herbicides Goal and Reflex have significant soil activity.

The organic arsenical herbicides DSMA and MSMA are often called contact herbicides, as are the cell membrane disruptors. However, their true mode of action is unknown. They are used to selectively control wide-leaved grasses such as crabgrass or dallisgrass in narrow-leaved grasses such as bermudagrass lawns. They are also very effective on cocklebur and common ragweed. These herbicides bind tightly to soil clay and organic matter, so they have no residual, preemergence activity

Herbicides in this category

Family	Common Name	Trade Name(s)
bipyridiliums	difenzoquat	Avenge®
	diquat	Diquat®, several others
	paraquat	Gramoxone Extra®, several others
diphenylethers	acifluorfen	Blazer®
	fomesafen	Reflex®
	lactofen	Cobra®
	oxyfluorfen	Goal®
organic arsenicals	DSMA	Several
	MSMA	Several

Symptoms

Plants rapidly turn yellow or pale and may look water soaked; then they dry up. The effects of the bipyridilium herbicides are rapid. Even small droplets that drift to nontarget vegetation cause specks of burned tissue. Roots of perennial weeds are seldom killed because these herbicides do not usually translocate to the roots.

Paraquat drift onto corn

The organic arsenicals accumulate in root and leaf tips and symptoms are first seen on leaf tips. They rapidly kill leaf and stem tissue. MSMA and DSMA are more effective on grass weeds than on broadleaf weeds, except for common ragweed and cocklebur. When applied over cotton to control grasses or cocklebur, they sometimes cause speckled leaf burn and red stems on the cotton plants; however, this has little effect on overall growth.

Special considerations

Be careful to prevent drift during application so that nontarget plants are not harmed. Applying systemic herbicides shortly after cell membrane disruptors or organic arsenicals is not advised. Paraquat and diquat are generally considered to be nonselective and harmful to both grass and broadleaf vegetation. In peanuts, however, some selectivity can be achieved by using paraquat at the cracking stage. Another bipyridilium herbicide called Avenge® is used in wheat and barley for selective postemergence control of wild oat.

MSMA damage on Johnsongrass

Lipid Synthesis Inhibitors

Lipid synthesis inhibitors are unique because they act only on annual and perennial grasses, not on broadleaf plants. With the exception of diclofop, these herbicides are applied postemergence and have little or no soil activity. Crop oil concentrate or some other type of adjuvant must be used to increase herbicide uptake into the leaf. To be most effective, these herbicides should be applied to actively growing grass weeds. If grass weeds are stressed and slow growing, these herbicides will be less effective.

Lipid synthesis inhibitor damage to corn. Note rotted appearance at the base of the leaf stem.

These herbicides disrupt lipid biosynthesis in grass plants. All plants contain lipids, which are fatty acids essential for plants to function normally. Plant cells contain lipid membranes. Membranes help the plant cell regulate what moves in, what moves out, and what remains out. Because these herbicides prevent the plant from producing fatty acids, membranes cannot form. Leaves absorb these herbicides quickly and within an hour they can not be removed by rain.

Herbicides in this category

There are two families of herbicides that disrupt lipid biosynthesis.

Family	Common Name	Trade Name(s)
cyclohexanedione	clethodim	Select®
	sethoxydim	Poast®, Poast Plus®
aryloxyphenoxy-propionate	fenoxaprop-P	Whip 360®, Option II®
	fluazifop-P	Fusilade DX®
	quizalofop-P	Assure II®
	fluazifop-P + fenoxaprop-P	Fusion®
	diclofop	Hoelon®

Symptoms

Symptoms develop slowly on grass plants and may not appear for 7 to 14 days. Initial injury is seen where the newest leaves are developing. These regions usually turn pale or yellow and then die. The area at the base of new leaves quickly becomes mushy, has a rotted appearance, and new leaves in the affected area can be pulled easily from the rest of the plant. Reddish blue pigmentation may also be observed on the stem sheath, leaf margins, and/or leaf blade.

Fluazifop-P damage on corn

Leaves absorb these herbicides quickly and within an hour they cannot be removed by rain.

Amino Acid Synthesis Inhibitors

Imidazolinone carryover to corn

These herbicides bind to a specific enzyme.

This new category of herbicides can be used at extremely low rates, controls both grasses and broadleaf plants, has soil and foliar activity, and is essentially nontoxic to mammals and most non-vegetative life forms.

Amino acid synthesis inhibitors bind to a specific enzyme and prevent the development of amino acids essential to plant life. The enzyme to which they bind is abbreviated ALS or AHAS, so these herbicides are often called the AHAS/ALS herbicides.

Herbicides in this category

Family	Common Name	Trade Name(s)
imidazolinone	imazethabenz	Assert®
	imazamox	Raptor®
	imazapic	Cadre®, Plateau®
	imazapyr	Arsenal®, Contain®
	imazaquin	Scepter®, Image®
	imazethapyr	Pursuit®
sulfonylurea	bensulfuron	Londax®
	chlorimuron	Classic®, Skirmish®
	chlorsulfuron	Glean®
	halosulfuron	Permit®, Manage®
	nicosulfuron	Accent®
	primisulfuron	Beacon®
	prosulfuron	Peak®
	rimsulfuron	Matrix®
	sulfometuron	Oust®
	thifensulfuron	Pinnacle®
	triasulfuron	Amber®
	tribenuron	Express®
triazolopyrimidine	chloransulam-methyl	FirstRate®
	diclosulam	Strongarm®
	lumetsulam	Python®
pyrimidinylthio-benzoate	pyrithiobac	Staple®

Symptoms

When these herbicides are applied preemergence, symptoms do not usually appear until the plants have emerged from the soil. Symptoms for grasses include stunting, purple coloration, and root systems that develop a "bottle-brush" appearance. On broadleaf plants, symptoms include red or purple leaf veins, yellowing of new leaf tissue, and sometimes blackened terminals.

Sulfonylurea residue injury to cotton

Special considerations

Herbicides in this category are very crop specific. The spray tank must be cleaned thoroughly before the sprayer is used on a potentially susceptible crop. It is very important that the susceptibility of future rotational crops be considered before herbicides in this group are applied. High soil pH increases the soil activity of sulfonylurea herbicides and the potential for rotational crop damage.

Imidazolinone carryover in cotton

Other Herbicides That Inhibit Amino Acid Synthesis

The herbicides in this category also affect amino acid synthesis but in a different way than the previous group. These herbicides are nonselective and control a broad range of annual and perennial grasses, broadleaves and sedges. Roundup Ultra®, one of the most commonly used herbicides on the farm and around the home, is in this category.

Herbicides in this category

Herbicides in this category have not yet been classified by family. Instead, they are grouped by the active ingredient or common name.

Family	Common Name	Trade Name(s)
unknown	glyphosate	Ranger®, Rodeo® Roundup Ultra®
unknown	sulfosate	Touchdown®
unknown	glufosinate	Liberty®, Rely®, Remove®, Finale®

Other Herbicides

Symptoms

Plants treated with glyphosate or sulfosate turn yellow in 5 to 7 days, then turn brown and die in 10 to 14 days. Glufosinate acts more quickly, in 3 to 5 days. An individual plant may have dead tissue, yellow tissue, and green tissue at the same time. Extremely low dosages of Roundup® cause leaf puckering.

Special considerations

Because these herbicides are nonselective, it is very important to protect desirable plants from spray drift. These herbicides bind tightly to soil clay and organic matter and have no soil activity. For that reason they may be less effective when plants are dusty or when application water is dirty.

Glyphosate injury to cotton

Glyphosate drift injury to sorghum

Because these herbicides are nonselective, it is very important to protect desirable plants from spray drift.

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